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LUMINARY MEMO #235, Revision 1.

TO: Distribution
FROM: D. Eyles
DATE: February 22, 1972
SUBJECT: Tentative EMP for Broken CDUX

This memo describes an erasable memory program (officially under the heading of EMP 103) which is thought to permit a landing under PGNCS autopilot control despite a failed CDUX. It is not, at this stage, recommended for use in flight.

The idea is simple -- and simple-minded. Every 20 ms., executed as part of the downrupt in the manner familiar by now to all dabblers in erasable memory programming, the EMP does its best to stop autopilot activity in the yaw channel. Specifically: (1) it zeroes the autopilot registers CDUX, CDUXD, DELCDUX, OMEGAPD, OMEGAP, and DELPEROR, actual angel, desired angel, desired rates, and rate estimate quantities; (2) it enlarges the autopilot deadband to about 3^{o}, and (3) it enables x-axis override.

Part two prevents the deadband from being violated by a runaway CDUX in the 20 ms. between zeroings. In that time, CDUX can count 6400/50 = 128 pulses = 1.4^{o}. The replacement value for the deadband -- which normally is 1^{o} in P63 and 0.3^{o} in P64 -- is chosen so that a single lost downrupt can be tolerated.

Part three is to prevent x-axis override from being locked out at 30000 feet altitude, since it is x-axis override that permits control in yaw. With this EMP in operation, the RHC acts as an acceleration command

stick. As long as the stick is out of detent, jet firings occur every 100 ms., their magnitude depending on the magnitude of the stick deflection. (This is similar to the AGS minimum impulse mode.) In a test of the hybrid simulator at MIT, with Sam Drake at the controls, this type of control seemed adequate to keep yaw within about 5^{o} of zero. (Note that if the redesignator is enabled, the pilot must be careful not to deflect the stick in pitch or roll when using it to control yaw.) An alternative way to control yaw with this EMP in operation is to switch briefly to AGS and correct yaw using the AGS autopilot, and then return to PGNCS.

On the basis of one test, run with a slightly simpler version on the digital simulator, and thus open-loop, it appears that if yaw is allowed to diverge too far from zero,control breaks down in the other two axes as well. The autopilot's idea of the transformation from stable-member to body axes at some point becomes so incorrect as to affect control in pitch and roll. How far is "too far" is an open question, although keeping yaw within 10^{o} of zero is probably sufficient.

Another open question is the effect of multiple, consecutive lost downrupts. Another is the question of the quality of control possible in pitch and roll with a deadband three times the conventional powered flight deadband, and ten times the deadband thought necessary in P64.

The details follow. I would like to hear what luck others have in running this program.

EMP FOR A FAILED CDUX

N26 load:

V 25 N 26 E 1 E 676 E 10100 E

Start-up procedure:

V 31 E

660	00000	reserves VAC5	
661	35006	CA	EBANK6
662	54003	TS	EBANK
663	34746	CA	ZERO
664	54660	TS	VAC5USE
665	54032	TS	CDUX
666	54634	TS	CDUXD
667	55637	TS	DELCDUX
670	55642	TS	OMEGAPD
671	55421	TS	OMEGAP
672	55274	TS	DELPEROR
673	30723	CA	723
674	55343	TS	DB
675	00710	TC	710
676	34746	CA	ZERO
677	54660	TS	VAC5USE
700	30703	CA	703
701	54335	TS	DNTMGOTO
702	05263	TC	TASKOVER
703	00661	starting address of EMP	
704			
705		unused	
706			
707			
710	44734	CS	XOVINHIB
711	70111	MASK	FLGWRD13
712	54111	TS	FLGWRD13
713	10752	CCS	PHASE1
714	03532	TC	DNPHASE2
715	05355	TC	PHASCHNG
716	07011	OCT	07011
717	77777	OCT	77777
720	00676	ADRES	676
721	10100	OCT	10100
722	03532	TC	DNPHASE2
723	02104	3° for deadband	